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ORIGINAL ARTICLE

Interacting dark sector and the coincidence problem within the scope of LRS Bianchi type I model

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Abstract It is shown that a suitable interaction between dark energy and dark matter in locally rotationally symmetric (LRS) Bianchi-I space-time can solve the coincidence problem and not contradict the accelerated expansion of present Universe. The interaction parameters are estimated from observational data.

Keywords Bianchi type I model · Dark energy · Anisotropic dark energy

1 Introduction

Currently dominated by dark energy (DE), it occupies almost 70% of the energy content of the Universe. DE provides acceleration of the Universe. Melchiorri et al. (2003) evaluated the equation of state (EoS) of DE: $-1.38 < \omega_{de} < -0.82$ at 95% confidence level. The simplest explanation of dark energy is provided by a cosmological constant (the vacuum energy), but the scenario has disadvantages.

The authors of Smoot et al. (1992), Bennett et al. (1996), Hinshaw et al. (2003, 2007), Nolta et al. (2009), Hinshaw et al. (2009) indicate anomalies in the observed cosmic microwave background (CMB) on the largest scale. A Λ-dominated cold dark matter (ΛCDM) standard model predicted a higher value of the quadrupole amplitude than the observed quadrupole. The Bianchi model can explain anisotropy of CMB (Ellis 2006). It can be assumed that the CMB features are consequences of the anisotropic nature of DE, since the anomalies of the CMB enter inside the horizon at the same epoch that the DE dominance begins. In the papers Rodrigues (2008), Koivisto and Mota (2008a,b), the model DE with anisotropic EoS is considered. Then the expansion rate of the Universe becomes direction dependent. The idea of anisotropic EoS parameter has spread, for example, in Muharlyamov and Pankratyeva (2018), Akarsu and Kilinc (2010), Yadav (2011), Yadav and Yadav (2011), Yadav et al. (2011), Saha and Yadav (2012).

Another problem of the cosmological constant is related to its energy scale. The vacuum energy density falls below the value predicted by any sensible quantum field theory by many orders of magnitude (Weinberg 1989), and it unavoidably leads to the coincidence problem, i.e., "Why are the vacuum and matter energy densities of precisely the same order today?" (Steinhardt 1997). More sophisticated models of DE (quintessence, tachyon field, phantom field or exotic equations of state) fit the observational data but it is doubtful that they can solve the coincidence problem (Chimento et al. 2000, 2003). In several papers, it has been proposed that dark matter (DM) and DE are coupled and do not evolve separately (Chimento et al. 2003, 2009; Amendola 2000; Tocchini-Valentini and Amendola 2002; Zimdahl et al. 2001; Zimdahl and Pavon 2003; Chimento 2010; Binder and Kremer 2006; Farrar and Peebles 2004; Kremer 2007; Huey and Wandelt 2006; Mangano et al. 2003; Cai and Wang 2005; Amendola et al. 2007; Guo et al. 2007; Boehmer et al. 2008). The coupling between DM and DE is motivated by high energy particle physics considerations (Amendola 2000). It is shown that the interacting models

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